FISH, DOG, AND CAT NUTRITION AND FEEDING

- *References: NRC (1993), Hirakawa (1998) in Kellems & Church (1998), Corbin (2001. Feedstuffs 73:70-75), and Jurgens (2002).*

FISH DIET FORMULATION AND PROCESSING

1. **General**

A. A primary objective in diet formulation? To provide a balanced mixture of ingredients to support the maintenance, growth, reproduction, and health at an acceptable cost!
B. Also, must consider some factors that can facilitate the manufacturing process to produce a diet with the desired physical characteristics.
C. The diet should be palatable & not contain antinutritional factors in the amount or concentrations that can reduce the performance.
D. The NRC's dietary requirements:

1) Fish size, metabolic function, management, and environmental factors have slight to profound effects on dietary nutrients needed for optimum performance. Thus, the NRC requirement data should be used with some discretion.
2) The NRC estimates were mostly made with purified diets containing highly digestible ingredients (i.e., the data represent near 100% digestibility), thus important to make some allowances for, e.g., bioavailability of nutrients and processing & storage losses when formulating diets using natural ingredients.
3) Unknown energy & nutrient requirements for some species? Can use the requirements established for a related species with some caution?

2. **Formulating Fish Diets**

A. Protein:

1) Usually, the first nutrient considered and adjust energy to provide the optimum ratio.
2) Must be balanced for indispensable amino acids.

B. Carbohydrate? - The amount varies with fish species, depending on their ability to use it as an energy source and processing requirements.
C, Lipids? - Select the type & concentration to satisfy essential fatty acid (EFA) and energy requirements.
D. Vitamins? - Mostly supplied from a supplemental premix because of uncertainty over the content and bioavailability of vitamins in the feedstuffs.
E. Minerals? - The content in feedstuffs is a bit more consistent (vs. vitamins?), thus usually make mineral supplementation based on the composition of the major ingredients.
F. Overfortification of labile nutrients?

1) Necessary as a safety factor in processed fish diets.
2) Amino acids, several vitamins, and inorganic elements are relatively stable to heat, moisture, and oxidation under normal processing and storage conditions.
3) But, some vitamins are subject to some loss, thus should include more than the established requirements?

G. Least-cost formulation using linear programming methods? - Commonly used for fish diets & diets for other food animals, and necessary to have:

1) Nutrient requirements of the animal.
2) Bioavailability of nutrients and the energy content of ingredients:

a) Important in making computerized substitutions among ingredients.
b) Values are often quite variable among fish and also among feedstuffs.
c) Some examples? (1) Cold-water fishes do not use carbohydrates as a source of energy as well as warm-water species, (2) digestibility of P is less for fish vs. livestock, especially for fish without gastric secretions, and (3) Lys in cottonseed meal is less digestible than the Lys in soybean meal.

3) Minimum and maximum restrictions on concentrations of various ingredients.

a) Can be placed on certain ingredients because of their effects on production process and palatability, or their potential adverse effects on fish performance, flesh quality, or water quality.
b) Examples?

(1) Fishmeal and other animal protein sources - Beneficial in catfish diets for reasons not explained on the basis amino acids, thus may specify a minimum?
(2) Cottonseed meal - Sometimes restricted because of free gossypol toxicity.
(3) Carotenoid concentrations - Should be controlled because of the effect of xanthophylls on undesirable yellow pigmentation to light-fleshed fish.
(4) Red pigmentation sources - Necessary for the diets of salmonids.

4) Cost of ingredients.

3. Some Common Ingredients for Fish Diets

A. Fishmeal - Prepared from good-quality, whole fish is one of the highest-quality protein sources commonly available.

1) It is also a rich source of energy, EFA, and minerals, and is highly digestible and palatable to most fishes.
2) Ones made from fish parts, such as waste from fish processing and canning plants:

a) Have less high-quality protein vs. ones made from whole fish.
b) High in ash, and can produce mineral imbalances, so . . .

B. Other animal protein sources?

1) By-products, such as meat and bone meal and poultry by-product meal, that contain about 45 to 55% CP. Quality is less vs. whole fish meal, and also the ash content is usually high because a larger proportion non-muscle tissues.
2) Flash or spray-dried blood meal - Rich in protein (80 to 86%) but low in Met and unbalanced in branched-chain amino acids.
3) Feather meal - High in CP (80%) but usually digestibility is low.

C. Soybean meal:

1) Universally available and has one of the best amino acid profile of all protein-rich plant feedstuffs.
2) For some fish, such as young salmon, soybean meal can be unpalatable, but others, such as channel catfish, readily consume diets containing up to 50% soybean meal.

D. Cottonseed and peanut meals:

1) Are concentrated sources of protein and have been used in fish feeds in the US, but limiting in Lys & Met.
2) Most cottonseed meals contain free gossypol, which is moderately toxic to monogastric animals and limits its use in fish feeds.

E. Others:

1) Lupin flour - Effectively replaces full-fat soybean flour as a protein source in feeds for rainbow trout.
2) Canola meal:

a) Has an amino acid profile comparable to soybean meal, but lower in CP and higher in fiber and tanins.
b) Has been used in experimental feeds for salmonids with success though.

F. Replacing fish meal or other animal by-product proteins with oilseed meals?

1) Must consider losses in energy, minerals, and lipids.
2) Examples? - Dehulled soybean meal contains 25% less ME for rainbow trout, 86% less available P for channel catfish, and 90% less (n-3) fatty acids than anchovy fish meal on an equal DM basis.

G. Carbohydrates - Primary nutritional contribution of grains.

1) Whole grains contain 62 to 72% starch, which is 60 to 70% digestible by warm-water fish, but less digestible by salmonids.
2) Starch in grains is important binding agent in steam-pelleted and extruded fish feeds.

H. Fats and oils:

1) Used as a source of energy to provide EFA, and to coat the outside of pellets to reduce abrasiveness and dustiness.
2) Marine fish oils are rich sources of essential (n-3) fatty acids, containing 10 to 25% of the highly unsaturated (n-3) fatty acids.

I. Ingredient quality?

1) Major ingredients - Should analyze for proximate composition & selected nutrients such as limiting amino acids (Lys and S-amino acids?) or EFA on a regular basis.
2) Animal by-products with high proportion of bones, feathers, or connective tissues should be subjected to in vitro enzyme assays to assess protein digestibility?
3) Should be tested for mycotoxins, pesticides, and other contaminants periodically?

4. **Feed Processing**

A. Should be processed into water-stable, particulate forms (granules, pellets) for efficient consumption by the fish and to minimize fouling of the water.
B. Compression pelleted or extruded feed is common, but also moist (or semimoist), microencapsulated, and micropulverized feeds are available.
C. Steam pelleting through compression:

1) Produces a dense pellet that sinks rapidly in water.
2) Involves the use of moisture, heat, and pressure to agglomerate ingredients into compact and larger particles.
3) Steam added to the ground feed mixture (mash) during pelleting assists in partially gelatinizing starch, which aids in the binding of the ingredients.
4) Must be firmly bonded to prevent rapid disintegration in water, which will reduce feed efficiency and water quality.

D. Extrusion:

1) The feed mixture in the form of a dough is forced through a small orifice at high pressure and temperature. Allows entrapment of water vapor by the feed particles, which, on drying, will float on water.
2) Usually the mixture of finely ground ingredients is conditioned with steam into a "mash" that may or may not be precooked before entering the extruder.
3) Contain more water than steam-pelleted particles, thus require external heat for drying. May end up with the loss of heat-sensitive vitamins such L-ascorbic acid.

4) Extruded feeds are firmly bound due to gelatinization of starch and denaturation of protein, which results in few fines and long water stability.
5) Extruded feeds are preferred by many producers, especially those feeding in large ponds, because they allow observation of the feeding process.

E. Granule diets for small fish

1) Prepared by pelleting the ingredient mixture and then reducing the size of the pellets by crumbling. Crumbled pellets are separated into various sizes by screening.
2) Fat is usually sprayed onto the surface of the particles after processing.
3) Considerable loss of water-soluble nutrients because leaching may occur with small-particle diets, which have large surface area?

F. Microencapsulation:

1) Coating of the diet with a thin layer of a compound to reduce disintegration, leaching, or bacterial degradation.
2) Materials should be water insoluble but digestible by enzymes in the digestive tract of the fish.
3) Microencapsulation and microbinding vary with the encapsulation material used & the substrate being coated. Nylon (N-N bonds) cross-linked proteins, Ca alginate, and oils have been used as encapsulation materials.

G. Moist or semimoist feeds

1) Prepared by adding moisture and a hydrocolloidal binding agent (e.g., carboxy-methyl-cellulose, gelatinized starch, or ground, wet animal tissue) with the dry ingredients, and forming the mixture into soft, moist pellets.
2) Advantages? - More palatable than dry diets for some species, no need for a steam-pelleting machine, and heating and drying are avoided.
3) Disadvantages? - Susceptible to microorganism or oxidation spoilage unless fed immediately or frozen. Fish parts should be pasteurized to destroy possible pathogens and thiaminase!
4) Not necessary to store some feeds frozen - May contain humectants (e.g., propylene glycol, which lower water activity below that will allow bacterial growth) and fungistats (e.g., propionic or sorbic acid).

5. **Other Dietary Components?**

A. Diets and ingredients contain materials other than nutrients that may affect metabolism positively or negatively. Naturally present or added for specific purposes.
B. Water:

1) Moist feeds (10-40%) have been used for Pacific salmon & Atlantic salmon - They prefer moist feeds under hatchery conditions.
2) In recent years, commercial semimoist (15 to 20%) diets that do not require refrigeration have been introduced:

    a) To reduce moisture loss during processing and storage & to improve texture. Use polyhydric alcohols - e.g., propylene glycol, glycerol, and sorbitol.
    b) Mold inhibitors are also required.

C. Fiber

1) Fish do not secrete cellulase, thus cellulose digestion does not play important role in their nutrition.
2) Some roles of fiber?

    a) Provide physical bulk to the feed, and cellulose & hemicellulose have been used as diluents & binders in fish diets.
    b) Some researchers reported that small amounts of supplemental cellulose increased growth and the efficiency of protein utilization.
    c) Diets with natural ingredients that contain 3-5% fiber? - No beneficial effect of adding fiber?

3) Most fish can tolerate up to 8% or so of dietary fiber, but higher concentrations can depress growth.
4) In most instances, the concern is excess dietary fiber, which can reduce nutrient intake and performance.
5) Try to use highly digestible ingredients & limit the fiber content to minimize an environmental impact?

D. Hormones

1) Various hormones have been evaluated in fish studies - e.g., Growth hormone, thyroid hormones, gonadotropin, prolactin, insulin, and various steroids.
2) Steroids:

    a) About 20 fish species have shown anabolic responses to steroids, but some warm-water species (e.g., channel catfish) have responded negatively.
    b) Prolonged steroid treatment for growth may cause detrimental side effects such as early gonadal development, skeletal deformity, increased susceptability to infections, and pathological changes in the liver.
    c) None has been approved by the FDA for growth enhancement.

3) Hormones have been used successfully to induce or synchronize ovulation & the stimulation of spermiation - e.g., Pituitary extracts & human chorionic gonadotropin.

4) Use of some sex steroids to reverse the sex of some species of salmonids, carp, and tilapias (e.g., feed ethynylestradiol, esterone, diethylstilbestrol, 17-β-estradiol, ethynyltestosterone, methyltestoterone, etc.) - Objectives?

   a) To produce monosex and sterile fish of the faster growing sex.
   b) Achieve better somatic growth.
   c) Prevent sexual maturation & the accompanying deterioration of flesh quality.

E. Antimicrobial agents

1) Only two antibiotics, sulfadimethoxine/ormetoprim & oxytetracycline, have been approved by the FDA for use in fish.
2) Stable under compression pellet processing & storage, but may lose some oxytetracycline with extrusion. Not much effect on sulfadimethoxine/ormetoprim.
3) Unlike with farm animals, antibiotics may not have beneficial effect on bacterial microflora of fish.
4) Chemotherapeutic compounds may be toxic or have adverse effects when administered for an extended period of time.

F. Antioxidants

1) Commonly used in fish feeds with a high concentration of polyenic fatty acids to prevent the oxidation of lipids. Ethoxyquin, BHT & BHA are most commonly used.
2) Breakdown products of lipid oxidation can react with the epsilon amino group of Lys & reduce its nutritional value.
3) Natural vitamin E has antioxidative activity, but synthetic form does not because it is in ester form in the diet, which has little antioxidative activity until hydrolized to alcohol form in the gut.

G. Pigments

A. Fish & brids use oxygenated carotenoids (xanthophylls) for pigmentation of skin, flesh, and plumage/feather. Fish cannot synthesize, thus rely on exogenous sources.
B. In salmonids, two oxycarotenoids, astaxanthin & canthaxanthin, are responsible for the red to orange coloring of the flesh, skin, and fins.

FISH FEEDING PRACTICES

1. General

A. Need to use different feeding strategies simply because of the difference in the size and species of fish and also the diverse environmental and management conditions.
B. Need to consider carefully some characteristics such as the particle size, texture, density, and palatability.

C. Feed allowance and frequency of feeding are important considerations for the rate & efficiency of growth.
D. Type of feed (floating or sinking) used and method of feeding would depend on the fish, the culture system, and the equipment and personnel available. And, these factors can be as important as meeting the nutrient needs per se.

2. Feeding Larval Fish

A. "Larval stage?" - Refers to the period of going through metamorphosis of external and physiological characters from hatch until the juvenile stage.
B. External traits & major organ functions of juveniles can be similar to those of adults.
C. Can be divided into three groups according to the alimentary tract morphology and the enzyme secretion:

    1) First group - e.g., Salmonids & channel catfish, which seems to have a functional stomach before changing from endogenous to external feed.
    2) Second group - e.g., Striped bass & many marine species with a very rudimentary digestive tract, which have no functional stomach or gastric glands & undergo complex metamorphosis of the digestive system.
    3) Third group - e.g., Carps, which develop a functional digestive tract but remain stomachless throughout life.

D. Larval metamorphosis & diets?

    1) Striped bass, which completes metamorphosis in 21 to 42 days, cannot use dry diets at day 5, when initial feeding begins, but they can at day 15.
    2) Common carp can be transferred to commercial dry diets at 15 to 30 mg, whereas larval whitefish must weigh 50 mg to be weaned to dry diets.
    3) Transition from live to dry diet must be a gradual process.

E. Utilization of prepared diets:

    1) Some fish may not be able to digest the protein from prepared diets at larval stages.
    2) Possible reasons?

        a) Low affinity of the proteolytic enzymes in the immature digestive tract, or lack/absence of particular enzymes?
        b) High feed consumption can increase the passage rate, thus low digestive efficiency. Larval fish may ingest 50 to 300% of their body wt/day vs. 2 to 10% for sub-adult fish fed to marketable size.
        c) Absence of hormones or their regulators, or factors in live feeds that can inhibit or stimulate hormone action in larvae.

F. Live feed

1) Better to feed food organisms in their natural diets, but rotifer (*Brachionus plicatilis*) and brine shrimp (*Anemia*) are the only zooplankters produced in mass quantities.
2) Some variations in the nutritional quality exist among sources of zooplankton from different geographical origins and culture conditions, especially the n−3 PUFA
3) Many fish are very sensitive to a deficiency of n-3 PUFA, thus may want to fortify live zooplankton with essential fatty acids?

    a) Feed the newly hatched zooplankton marine algae (*Chlorella* spp.) or yeast high in n-3 PUFA for a period of 24 hr.
    b) Expose zooplankton nauplii to a suspension of lipid rich in n-3 PUFA, such as fish oil, and an emulsifying compound for 3-12 hr before being offered.

G. Prepared larval fish diets

1) Must meet the nutritional needs, have to be appropriate size for ingestion, must have the desired physical properties with regard to buoyancy, texture, and color; and also may have to simulate the movement in many instances.
2) Nutritional components:

    a) Should be based on the juvenile fish requirements, but inadequate info on the differences in nutrient needs between larval fish and juveniles.
    b) But, obviously, larval fish have a higher metabolic rate, thus may benefit from a higher dietary concentration of nutrients and energy.

H. Feeding:

1) Optimum diet particle size? - Increases in proportion to fish size and should not exceed 20 percent of the mouth opening.
2) Frequent feeding is important in all larval fish, and can be offered 10 to 24 times a day or almost continuously and in excess.
3) Diets containing 70 to 80% good-quality fishmeal support good growth in starter feeds for salmonids and channel catfish.
4) Diets based on single-cell protein and freeze-dried animal tissues have been proved successful with the stomachless larvae of common carp, grass carp, and silver carp.

3. Channel Catfish

A. Channel catfish:

1) Have a relatively well-developed digestive system, and consume & utilize prepared diets well at the time the fish begin feeding.
2) When to initiate feeding? - When the yolk sac reserves have been depleted and the fish "swim-up" to the surface in search of feed.

B. "Swim-up" fish - Can be fed at hourly by automatic feeders at a rate of 25% of body wt per day, and reduce to 4 to 2 feedings of 5 to 10% of body wt as fish size increases.

C. A popular commercial practice?

1) Transfer from the hatchery to prepared nursery ponds, which have a good population of feed organisms & free of predators, within a few days after the beginning of feeding.
2) Feed diets in the pond twice a day at the rate of 10% & decreasing to 3% of body wt per day for the remainder of the growing season.
3) Initially, nursery pond diets should be 2- to 3-mm crumbles, and later, small pelleted or extruded particles of 3 to 5 mm diameter can be used.

D. Catfish production in the US:

1) Feed extruded diets in large ponds (5 to 10 ha in size):
   a) Extruded diets can float on the water surface & allow observation of the fish during feeding.
   b) Can feed closer to their maximum rate without overfeeding, and also disease and water quality problems can be detected more easily.
2) The use of pellets that sink can reduce feed costs by 10 to 20% vs. floating feeds, but need more management.
3) Using a combination (85% sinking & 15% floating) saves 10 to 15% in feed costs and still allows the management benefits of the floating feed.
4) To minimize wasted feed, most catfish farmers do not feed completely to satiation in large ponds.

F. Others? (See the table on "Examples of natural ingredient reference diets")

Examples of natural ingredient reference diets (NRC, 1993)

	Guelph Salmonid[a]	Paciifc Salmon[b]	Channel Catfish[c]
Ingredient, %			
Fishmeal			
Herring	30	50	-
Menhaden	-	-	8
Soybean meal	13	-	50
Corn gluten meal	17	-	-
Corn	-	-	34.1
Wheat middlings	16.5	12.2	5
Dried whey	10	5	-
Blood meal	-	10	-
Condensed milk solubles	-	3	-
Poultry by-product meal	-	1.5	-
Wheat germ meal	-	5	-
Dicalcium phosphate	-	-	1
Fish oil			
Marine	11.5	9	-
Catfish	-	-	1.5
Vitamin mixture[d]	1	2.2	0.2
Trace mineral mixture[e]	1	0.1	0.2
Pellet binder	-	2.0	-
Composition			
CP (N x 6.25), %	38	50[g]	32
DE, kcal/g	4,100	4,200[g]	3,000

[a]Source: Cho, C. Y. 1990. Food Rev. Int. 6(3):333-357; [b]Source: Hardy, R. W. 1991. Pages 105-121 in Handbook of Nutrient Requirements of Finfish, R. P. Wilson, ed. CRC Press, Boca Raton; [c]Robinson, E. H. 1991. Miss. Agric. For. Exp. Sta. Bull. 979; [d]Vitamin mix should meet the vitamin requirements for the species with an allowances for processing and storage losses; [e]Mineral mix should provide the following quantities in mg/kg of diet for the following diets: Guelph salmonid - Cu = 6.25, Fe = 13.2, Mn = 21.5, I = 6, Zn = 52, & NaCI = 3,000; Abernathy Pacific salmon - Zn = 75, Mn = 20, Cu = 1.5, & I = 10; Channel catfish - Zn = 100, Fe = 30, Cu = 5, I = 5, Mn = 2.5, Se= 0.3, and Co = 0.05; [f]Estimated.

1) Traditionally, fish are fed once daily, 6 or 7 days per wk, but fed twice daily when the water temperature is above 25°C, which increase both intake & growth by 20% or so.
2) Feeding 7 days per week allows for 17% more feed to be consumed and 19% more growth than in a 6-day regimen, according to some.

3) Should not be fed late at night or very early in the morning when dissolved oxygen (DO) in the pond water is low.
4) Generally, catfish do not eat consistently with the water temperature below 21°C.

    a) A recommended guide for winter feeding of catfish in ponds? Provide a daily rate of about 0.75% of their estimated wt when the water temperature at 1 m depth is equal to or greater than 13°C.
    b) Fingerling fish can be fed 1% of body wt three times per week or daily with extended periods of warm weather.
    c) Feed low-CP diets (25%) to market-size fish (> 0.25 kg) during winter.

4. Tilapia

A. Culture systems and husbandry methods used for producing tilapia (*Oreochromis* and *Tilapia* spp.) seem to be very diverse.
B. Usually, produced in ponds with "low-cost" diets because tilapia are efficient feeders of natural aquatic feed organisms:

    1) Thus, perhaps not necessary to balance nutrients in diets when natural feeds are important sources of nutrients?
    2) But, need nutritionally complete feeds when the fish are stocked at high densities in tanks, raceways, net pens, and ponds, and natural feed is absent or insignificant.

C. Nutrient requirements/feeding?

    1) Nutritional needs seem to be similar to other warm-water fish, and commercial diets for channel catfish and common carp have been used successfully. (See the table on "Examples of natural ingredient reference diets" for channel catfish that can be fed to Tilapia.)
    2) Prefer smaller pellets vs. channel catfish & salmonids of comparable size - 3 to 5 mm in diameter for the most common marketable size of 0.5 kg.
    3) Respond to more frequent feeding vs. channel catfish and salmonids. (See the table on "Daily feeding allowances & frequencies.")

Example of daily feeding allowances & frequencies for Tilapias at 28°C

Size	Feed, % BW	Times fed/day
2 d - 1 g	30-10	8
1-5 g	10-6	6
5-20 g	6-4	4
20-100 g	4-3	3-4
> 100 g	3	3

Sources: Kubaryk, 1980. Ph.D. Dissertation. Auburn Univ., Auburtn University, AL; Jauncey & Ross, 1982. A Guide to Tilapia Feeds and Feeding. Univ. of Sterling, Sterling, U.K.

5. Striped Bass and Hybrid Bass

A. Striped bass & striped bass x white bass hybrids - Becoming an important aquaculture fish in the US.
B. Because of the condition of inland water for spawning, must obtain larvae & juveniles from hatcheries.
C. Larvae:

1) Usually start on small brine shrimp nauplii or rotifers at day 4 to 5 posthatch, and nauphi in the rearing container is maintained at 10 to 100 nauphi per mL.
2) May start feeding dry larval diets with appropriate size on day 5 to 8 and gradually replace all of the live feed by days 14 to 28.
3) Release the larvae into prepared nursery ponds with heavy zooplankton populations as early as 5 days after the larvae begin to feed.

D. Are voracious feeders, and respond to multiple daily feeding & can grow rapidly.
E. Respond to diets high in CP (36 to 45%) & fishmeal, but not much info on their preferences for energy sources.
F. Young fish need dietary eicosapentaenoic or docosahenaenoic acid for normal growth.
G. Commercial trout and salmon diets may be used successfully in rearing from juveniles to marketable size. (See the table on "Examples of natural ingredient reference diets" for salmon that can be fed to bass.)

6. Rainbow Trout

A. Start feeding as soon as fish deplete their yolk sac and begin to swim up:

1) Should be capable of consuming dry, prepared diets.
2) Feed at least once every hour during the normal light hours & can overfeed slightly to ensure adaptation, as long as left-over feed is removed regularly.
3) Water temperature should be kept above 6°C for swim-up fry.

B. Feeds/feeding:

1) Should use appropriately sized granules or pellets, and may have to screen to remove particles that are too small for the fish, and to prevent fouling of the water.
2) Optimum size? - 0.5 to 1.5 mm granules for 1 to 10 g, 2 to 3 mm granules for 20 to 40 g, 3 to 4 mm pellets for 50 to 100 g, and 5 to 7 mm pellets for fish over 200 g.
3) Overfeeding - Can reduces feed efficiency & increase the nutrient discharge, thus close observation is necessary or use an appropriate feeding guide!?
4) Daily feed allowances? - Varies with the size, strain, water temperature, feeding frequency, and energy concentration of the diet.
5) Feeding can be done by hand, usually twice daily, or by mechanical devices at predetermined amounts with appropriate feeding frequencies.

7. Pacific Salmon

° Terminology? Parr = a young salmon during its first two years of life; Smolt = a young salmon at the stage intermediate between the parr and the grilse; Grilse = a young Atlantic salmon on its first return from the sea to fresh or brackish waters.

A. In the US, common to rear the fish to smolt stage in freshwater hatcheries & then release for migration to the Pacific Ocean & return to near shore areas after reaching adulthood.
B. Some are grown from postjuvenile to marketable size in net pens on the Pacific coast of North America, in South America (Chile), South Australia, and Japan.
C. Feeds/feeding: (See the table on "Examples of natural ingredient reference diets")

1) Start with a meal diet (< 0.6 mm), and as the size increases, use crumbles (0.8-2.0 mm), then to pellets (> 2.0 mm).
2) Should feed frequently, and automatic feeders with hourly feeding are often used.
3) Starter diets should contain at least 40% CP with whole fish meal being one-half of the diet.
4) Many hatcheries feed moist pellets to enhance intake, but dry compressed (pelleted) or extruded diets have replaced moist diets in many because of the reduced cost & elimination of the need for frozen storage.
5) Extruded feeds that float or sink slowly are often fed in net pens:

a) Porous, low-density feeds can absorb more oil vs. compressed pellets.
b) Give the fish more time to consume the feed before it sinks through the net.
c) Give the feeder a better opportunity to observe feed consumption.
d) But, would be expensive vs. compressed pellets!

6) Semimoist diets (18 to 22% moisture), which do not require frozen storage, are also used, and may be more palatable than dry diets to young salmon?
7) Must contain carotenoid pigments to give the flesh a pink-red color:

a) May have to include sources of astaxanthin and canthaxanthin (. . . crustacean meals or oils, dried Phoffia yeast, and certain algae contain astaxanthin).
b) 40 to 50 mg of carotenoid per kg of diet fed for about 6 mo is needed to obtain satisfactory flesh color.

8) Hand feeding twice daily- Common in growing from postjuvenile to food-size:

a) Can provide "contact" with fish & also more growth vs. once-daily feeding.
b) Automatic feeders can reduce labor costs & also can feed more often throughout the day, but should watch for a possibility of wasting feed, underfeeding, etc.

8. **Atlantic Salmon**

A. Atlantic salmon farming is relatively new enterprise & involves two phases:

1) Juvenile freshwater stage - The fish grows from fry to smoltified postjuvenile, which lasts approximately 1.5 years.
2) Saltwater phase - May last for 2 years with the targeted market size of 4 to 6 kg.

B Atlantic salmon fry can use prepared, dry diets as their first feed:

1) Begin with a finely ground (< 0.6 mm) mash diet, change to crumbles, and then change to small compressed pellets during the freshwater stage.
2) Usually, starter diets contain more than 50% high-quality fish meal and 10-12% marine fish oil.

C. Relatively little information is available on the nutrient requirements, but functional commercial diets have been formulated from the data for rainbow trout and Pacific salmon, and also from feeding trials with natural ingredient diets.

D. Both moist and dry grower diets are being used. (See the table on "Examples of natural ingredient reference diets")

1) Moist diets - Contain dry ingredients supplemented with raw fish parts or fish ensilage, which are highly palatable but generally more expensive.
2) Dry, compressed, or extruded diets - Can be used, and slowly sinking extruded diets have become popular because of some reasons mentioned before for other fish.
3) Protein sources - Used fish meal as a primary source in the past, but as much as 20% soybean meal can be used successfully.
4) Over 20% lipid (as fish oil) is commonly used in commercial grower diets that contain 40 to 45% CP - More lipids than other species & can result in high body fat, and this practice is being questioned.
5) Approximately 50 mg of carotenoid, as astaxanthin or canthaxanthin, is added per kg of diet and fed for 1 yr for satisfactory flesh pigmentation.

E. Feeding:

1) Atlantic salmon may have a smaller stomach than rainbow trout, thus may have to feed more often.
2) Recommendation? "5- to 10-min" feeding intervals for fry and "30-min" intervals for parr.
3) Automatic feeders are often used in hatcheries, and fish in net pens are usually hand fed at least twice daily.

NUTRITION OF DOGS AND CATS IN GENERAL

1. Introduction

A. Archeological records indicate that the special relationship between humans & dogs is at least 12,000 yr old, and perhaps the first domesticated canid appeared before the agricultural phase.
B. Both domestic dogs & cats are members of the order *Carnivora*, and possess anatomical features that have supported their feeding behavior through evolution:

1) Canine teeth allow them to successfully catch & consume prey.
2) The carnassids, flat molars, facilitate the reduction of food particle size to ease the swallowing of prey.
3) Although both are classified in the same order, considerable distinction between the domestic dog and cat because the divergence of order occurred early in the evolutionary pathway.

C. The tremendous breed variation seen in today's dogs may have been, perhaps, the result of 12,000 years of selective breeding, but unlike dogs, few anatomical changes have occurred in the cat during its domestication.

2. U.S. Pet Food Industry

A. In the US, there are estimated 67 million dogs and 65 million cats?
B. The US pet food industry? A $11.8 billion enterprise (. . . & $28 billion business on the worldwide basis) and continues to grow 4-6% annually.
C. Manufactures the equivalent of 870 railroad boxcar loads of pet food every working day (each boxcar load = 40 tons of pet food).
D. Importance for US agriculture?

1) To produce 8.8 million tons of dry pet foods each year, use 3.6 million tons of corn, 1.07 million tons of soybeans (to make soybean meal), and 1.5 million tons of poultry, swine, and beef byproducts.
2) Others? - Corn gluten meal, wheat and wheat byproducts, brewers dry yeast, sorghum and corn oil.

E. Each year from 1997 to 1999, introduced 58-400 new pet food products within the US.
F. Reasons for the increase in consumer expenditures? Attributable to changing demographics and lifestyle trends?

1) More anthropomorphic considerations for their pets.
2) More elaborate and specialized pet food products with advanced nutritional information & packaging.
3) Give "end-of-the-day" treats to their pets following a day away at work?

G. The pet food industry:

1) Tends to be more defined than the human food industry and relies heavily on nutritional databases based on the Food & Drug Administration and the Association of American Feed Control Officials (AAFCO) with input by USDA & the Pel Food Institute.
2) AAFCO's Dog & Cat Food Nutrient Profile:

a) Based on extensive research and data generated and confirmed by extensive testing by universities and the pet food industry.
b) Unlike NRC guidelines, not minimum requirements but are "working successful guidelines!"

H. Designer foods? - "Gourmet foods" are now available for dogs and cats with human food grade, and they are increasing in popularity, the number of products, and tonnage!

NUTRIENT REQUIREMENTS OF DOGS AND CATS

1. General

A. The nutrient needs of today's dogs and cats can be satisfied in a variety of ways through the use of commercially available diets.

1) No need for pet owners to become a nutrition specialist to provide good nutrition to their pet.
2) Can choose from hundreds of brands of pet food to achieve optimum nutrient intake, economically & conveniently.
3) Nutritional information is relatively abundant from manufacturers of pet foods in both published literatures and advertising.

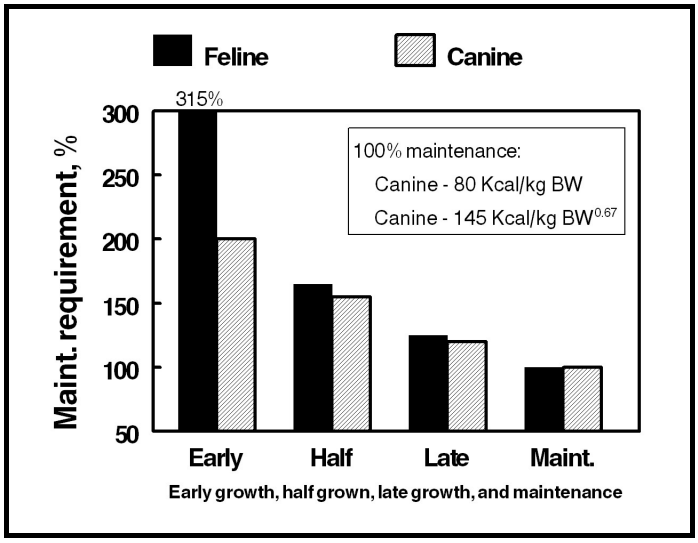
B. Estimation of the requirements can be complicated by the wide variation in size, performance, physical exertion, reproduction, age, environmental and psychological stress, etc.

1) A paucity of information exists on definitive nutrient requirements related to breeds, age, and sex.
2) Even with some suggested requirements, a substantial variation exists, which is not really surprising considering those factors plus breed diversity, especially in canine species.
3) The requirements cannot be defined simply as being at a single level, rather should be given as a range!?
4) Optimum nutrition often requires nutrients above the minimum requirements, and the final determination must be based on pet's response to a particular feeding regimen.

2. Water

A. Often overlooked, but is of utmost importance, and dehydration is a primary concern in growing puppies and kittens because of their high body water content.

B. Can be provided by the moisture content of food, metabolic water, and drinking water:



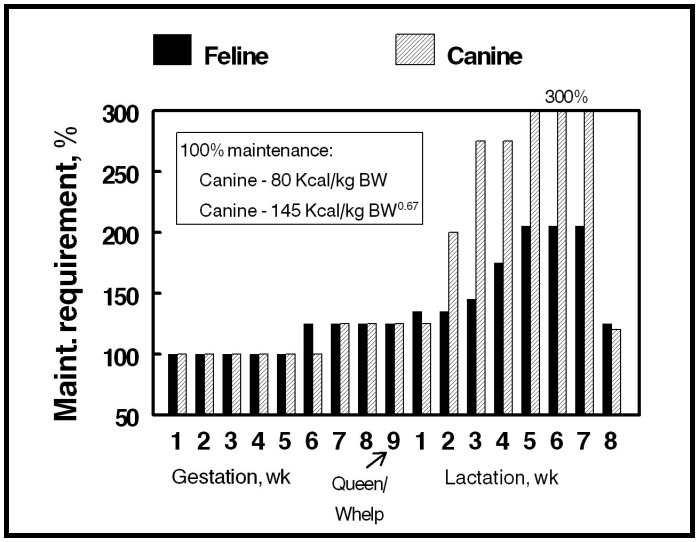
1) Water content of commercial diets can range form 10 to 78%, thus the consumption of water would vary accordingly.

2) In general, a dog gets about 25% of the requirements from drinking water, but a cat get only 10% from drinking water.

3. Energy

A. See figures on "Feline & canine ME requirements for growth (1st)" & "Feline & canine ME requirements for production (2nd):" [Redrawn from Hirakawa (1998)].

B. Energy needs of dogs and cats:



1) Affected by the animal's metabolic efficiency, environmental factors, physical exercise & activity level, age, and the stage of production.

2) The energy needs per unit of body weight decreases as the size of the animal increases, just like any other warm-blooded animals.

C. Animals fed a balanced diet tend to eat to satisfy their energy need, thus diets can be compared in terms of a nutrient per unit of energy.

4. Carbohydrates

A. Grain starches provide an important and economical source of dietary energy in most pet foods.
B. Limited information on this area, but a dog can utilize up to 65 to 70% dietary carbohydrates, whereas a cat can utilize only about 35 to 40%. Because the cat has active hexokinase but does not have glucokinase? Dogs have both!
C. Fiber:

    1) Inclusion of small amounts is necessary for the normal function of the GI tract by providing the bulk, maintaining normal passage rate & intestinal motility, and maintaining the structural integrity of gastrointestinal mucosa.
    2) Common sources? - Wheat middlings, citrus, beet pulp, soy hulls, peanut hulls, etc. Also, grains & plant protein sources can contribute fibers.
    3) Fermentation of fiber (i.e., VFA) may contribute as energy source for the cells lining the intestine.
    4) Certain types of fiber (e.g., fructooligosaccharides) may be beneficial in the treatment of some gastrointestinal diseases?
    5) Just like other nonruminant species, too much fiber can have some adverse effects!

5. **Lipids**

A. In pet foods, fat serves as a concentrated form of energy, a carrier for fat-soluble vitamins, a source of essential fatty acids, and an enhancer of diet palatability.
B. The optimum content? - Depends on other nutrients, e.g., as low as 5-10% in low-CP or inferior-quality protein, but can increase concomitantly with the increase in the CP and(or) protein quality.
C. Dogs and cats need linoleic acid, and cats also need arachidonic acid because they don't have appropriate enzymes to convert linoleic to arachidonic acid.
D. Common sources? - Tallow, lard, poultry fat, and many vegetable oils. Animal sources, especially fish oil, are appropriate source of arachidonic acid, but not plant sources.
E. Omega-3 & omega-6? - A proper proportion of these two may have beneficial effects on some disorders, such as treatment of allergic skin disorders in dogs, according to some studies.

6. **Protein**

A. Ideally, an intact protein source would supply all 10 indispensable amino acids in adequate amount, but there are considerable variations in the protein quality among various sources.
B. Also, relatively little is known about the quantitative amino acid requirements for canine and feline, and factors affecting the requirements.

    1) Some studies led to the quantitative assessment of amino acid requirements, and the resulting minimum requirements were incorporated into the NRC guidelines.
    2) Because those were the minimums established with purified diets, the AAFCO Nutrient Profiles added some safety margins.

C. Protein sources?

1) Plant protein sources, such as soybean meal and corn gluten meal, and animal protein sources, such as poultry, meat and respective by-products, are common ingredients in pet foods.
2) Although cereals are a major source of energy in cereal-based products, they also supply a substantial portion of protein:

    a) Often, those are deficient in some indispensable amino acids.
    b) Thus, fresh meats, meat and poultry meals, and various meat by-products are often added to alleviate the deficiency.

D. As in other nonruminant species, the indispensable amino acid requirements are affected by the age, sex, and breed/genetic potential of the animal - some e.g.?

1) Young puppies may not be affected by sex, but Lys requirement is higher for the immature male beagle vs. the immature female.
2) Labradors may have higher S-amino acid needs than beagles, and also S-amino acid needs of pointer puppies are different from beagles or labradors.

E. Cats, a strict carnivore, is unique in its protein/amino acid needs:

1) Have substantially higher requirements than the dog because of the high activity of the amino acid catabolic enzymes in the liver.
2) May not be a practical importance, but cats are very sensitive to a deficiency of Arg, which (i.e., devoid of Arg) can lead to hyperammonemia in less than hour.
3) Cats also have a higher S-amino acid needs relative to other mammals because of the needs for the cat's thick hair coat, which is high in cysteine. Perhaps, the reason for its high protein requirement!?
4) The amino acid, taurine, is uniquely important for cats.

    a) Synthesized form Met & Cys in the liver & other tissues, and the amount synthesized is sufficient in dogs but not in cats.
    b) Present in bile as taurocholic acid and in high concentrations in the retina & olfactory bulb.
    c) Unlike the dog, conjugates cholic acid exclusively with taurine & is unable to alternate between taurine & glycine conjugations in the production of bile:

        (1) Can lead to a reduction in conjugated bile acids & central retinal degeneration can develop.
        (2) Typically, reduced visual acuity, without total loss of vision, has been seen in older kittens & adult cats.
        (3) Also, may be associated with cardiomyopathy & poor reproductive performance.

d) Thus, the cat has a continual dietary need for taurine, which is only present in animal protein sources.

7. **Vitamins and Minerals**

A. Vitamins

1) A quality-stable fat source should be used to ensure fat-soluble vitamin absorption - Many add an antioxidant.
2) Water-soluble vitamins are carefully selected & added in excess of minimum needs to compensate for losses associated with heat processing and extended shelf life.
3) Conversion of β-carotene to vitamin A in cats:

a) Cannot convert because of a deficiency of the intestinal enzyme, β-carotene-15-15'-dioxigenase, thus they need dietary source of preformed vitamin A.
b) Also, cats may be susceptible to vitamin A toxicity because of no regulation at the intestinal mucosa. Readily absorb vitamin A?

4) Niacin - Cats have a unique dietary need for niacin because of they cannot synthesize it from Trp.

B. Minerals

1) A paucity of information on quantitative and qualitative mineral requiremnts for dogs and cats.
2) Tn ensure dietary adequacy, pet foods are fortified with essential minerals.
3) Ca:P - The proper ratio is about 1.2:1 (1:1 for cats & 1.2 to 1.4:1 for dogs?), and common sources of Ca are bone meal, skim milk, and alfalfa leaf meal, whereas bone meal & meat scraps can supply P. Vitamin D is needed for the utilization of Ca & P.
4) Many dog owners feel that growing puppies need additional Ca to prevent skeletal problems, but supplementing previously adequate diet with Ca may have no beneficial effect & actually it may have some adverse effects!

COMMERCIAL PET FOODS AND TABLE SCRAPS

1. **Dry Pet Foods**

A. The most common type of pet food in the U.S.:

1) Has been a trend toward increased sale of dry dog food & decreased sale of canned dog food in recent years.
2) A trend toward increased sale of both canned and dry cat foods.

B. Dry foods:

1) Commonly contain whole or dehulled cereal grains, cereal byproducts, soybean products, animal products, milk products, fat and oils and mineral and vitamin supplements.
2) Cereals are heat-treated to dextrinize starches and improve their digestibility.
3) Enough fats are added to increase the energy density, and adequate amounts of vitamins & minerals are carefully blended throughout the meat and cereal mixture.
4) Most mixtures contain about 6 to 10% moisture and the average energy value is 1,500 to 1,600 kcal/lb or 300 to 400 kca1/8 oz. cup.

C. Three main types of dry foods:

1) Dry meals:

a) May be pelleted or pelleted and then crumbled to a uniform particle size.
b) May be fat-coated, which increases their energy density and enhances the palatability.

2) Kibbles:

a) Ground together cereal grains & dried meat scraps along with dairy products, vitamins and minerals into a flour, blended with water & formed into a dough.
b) May be baked on a large sheet and then crumbled or "kibbled" into uniform-sized fragments.

3) Expanded dry foods:

a) Mixing raw grains, meat meal, vegetables, dairy products, vitamins, and minerals with steam inside a blending pressure cooker, which allows the ingredients to be cooked while being whipped into a homogeneous mixture.
b) A mixture would be pushed through a die and expanded with steam and air into small porous nuggets, which are hardened by passing through heated air streams.
c) Then, the hardened nugget is usually passed through a spray chamber & coated with a liquid fat, carbohydrate or milk product to provides additional energy or palatability.

2. **Semimoist Foods**

A. Represent a very diverse group of products & very convenient to feed, but have fallen in popularity in recent years. Increase in the variety of semimoist "treats & snacks" though!
B. The moisture content is about 23 to 40%, and generally contain a mixture of soybean meal, corn syrup, fresh meat or meat by-products, animal fat, vitamins, and minerals together with preservatives and humectants.

1) Phosphoric, hydrochloric, and malic acids are commonly used acids to lower the pH to retard bacterial growth and spoilage.
2) Sugars, corn syrup, and salts elevate the soluble solids in the product and bind the water so it is unavailable to bacteria and fungi.
3) Propylene glycol is hygroscopic and binds moisture in the product to keep the food pliable and prevent drying, but has been banned by the FDA to use as a humectant because of potential risk to cats.

C. Commonly packaged with cellophane or foil in portion controlled servings, and can be stored unrefrigerated because of the preservatives and humectants - Often shaped and colored to resemble meat chunks or hamburger patties.

3. **Canned Foods**

A. Extremely popular, especially for cats - The canned cat food market has grown dramatically in recent years.
B. Fresh, wet ingredients are sealed into containers (generally cans) to prevent any recontamination and then subjected to a heat-sterilization process to destroy any microorganisms of spoilage already in the food.
C. Types of canned foods:

1) Ration-type canned foods - Ground fresh meat and meat byproducts along with fat, water, and cereal ingredients are blended to make a complete balanced diet.
2) Gourmet or meat-type canned foods:

a) Look like containing a substantial amount of meat but actually contain a variety of animal byproducts and textured vegetable protein, which is composed of extruded soy flour mixed with red or brown coloring.
b) The high protein content requires the animal to use protein as its major energy source.
c) Because of their high protein and fat content and high palatability, excellent to feed when food intake is decreased because of anorexia from any cause & when protein requirements are increased (. . . such as for extensive wound healing & protein losing nephropathy or enteropathy).
d) The canned gourmet cat foods:

(1) Extremely palatable, and a good diet to try to induce voluntary food intake in either the anorectic dog or cat.
(2) Composed primarily of animal tissues such as shrimp, tuna, kidney, liver, and chicken and numerous combinations.
(3) Because of high palatability, cats frequently become addicted to a specific ingredient?

4. **Table Scraps**

A. Frequently quite palatable to dogs but generally not nutritionally balanced.
B. Most table scraps are fats and carbohydrates, yielding lots of energy and little else. The dog may obtain a sizeable portion of its daily energy need from the useless scraps & lose appetite for the commercial food.
C. Spicy food should not be given to any animal.

FEEDING OF DOGS AND CATS

1. **Feeding Methods & Some Tips**

A. Three methods of feeding dogs and cats:

1) Free-choice, ad libitum, or self-feeding. Allowed to eat as much as it wants and whenever it chooses because foods are made available all the time.
2) Time restricted meal-feeding - Offered more food than it will consume within a specified period of time, generally 5 to 30 minutes.
3) Food restricted meal-feeding - Offered a specific but less amount of food than it would eat if the amount fed were not restricted.

☛ Meal-feeding are repeated at a specific frequency such as once or twice a day.

B. Some people use only one, while others use a combination of methods - e.g., Provide a dry or soft-moist food free-choice & meal-feed a canned food or specific food(s) such as meat, table scraps etc.
C. The method can be determined by the type of food used:

1) Dry foods - Can be self-fed successfully to most dogs and cats, but some will overeat & become obese or have some digestive disturbances.

a) The dry food's abrasive action on the teeth help keep them scaled and clean.
b) Gum exercise is also provided by the chewing of the dry food.
c) Not eating enough? - Some problem such as sore gums or lips or bad teeth?

2) Canned foods, fresh foods, and moistened dry foods:

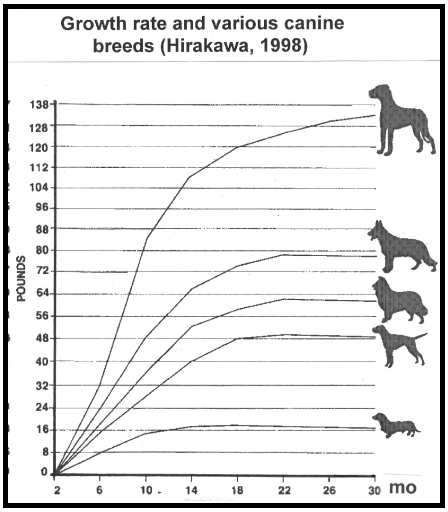
a) Should be opened or prepared fresh daily and not exposed to the air for more than 10 to 12 hr during summer because of possible spoilage!
b) An alternative? - Set a regular feeding time so that the owner can check on the animal's appetite each day, and uneaten food should not be in front of them for more than 30 minutes, especially during warm weather.

D. Avoid between-meal snacks and table scraps because of possible unbalanced nutrition, obesity, digestive disturbances, and development of a finicky eater or food beggar. Should not constitute more than 25% of the animal's ration.

E. Poultry bones, chopped bones, or small bones may lodge in the animal's mouth or gastrointestinal tract, whereas large bones may result in broken teeth.
F. Although most adult dogs eat rapidly and voraciously, many dogs are inhibited-type eaters & prefer to be left alone while eating.
G. Most cats like to eat alone and without distractions or worry of competition - If feeding more than one, should have separate bowls and their bowls should be separated.
H. Regardless of the method of feeding used for cats, best to feed a ration type of cat food and to feed on a regular schedule.

2. How Much to Feed?

A. The amount of food to be given to the dog or cat?



- See the figure on "Canine breed growth rates (Hirakawa, 1998)" - Growth curves would certainly affect how to feed the pet!

1) Determined by trial and error, energy need, and a rule of thumb?
2) Most household pets consume about ⅓ to ½ oz of dry matter food/lb of body weight when they are inactive/at maintenance.
3) Puppies may consume about three times this amount during the fast growing period.
4) Hardworking and lactating dogs will consume up to three times the maintenance.
4) When canned diets are fed, about three times as much by weight is needed as when dry foods are fed.

B. Some variations/adjustments?

1) The amount consumed by individual dogs vary, and two related dogs of the same strain may require different levels of food intake to maintain their body condition.
2) Heavy exercise increases the nutritional requirements, and a good dog may lose up to 20 lb during the hunting season.
3) Cold weather will increase the requirement of food.
4) The size of the animal must be considered - A small dog will require more food per lb than will a large dog.
5) Nervousness is another factor - Purebred breeds have a tendency to be more nervous and need more food, but they are always thin and often have a diarrhea problem.
6) Spayed and castrated animals need one third to one half as much food than they needed originally because of less natural exercise.

3. Feeding During Pregnancy and Lactation

A. The primary goal? - Obviously to provide a nutritionally balanced diet!
B. Diets for dogs?

1) Can be fed a canine reproduction or growth diet throughout pregnancy but is needed especially during the last 3 to 4 wk of pregnancy & during lactation.
2) The diet on DM basis should be at least 80% digestible & contain at least 25% CP, 17% fat, 1,750 kcalME/lb, less than 5% fiber, 1-1.8% Ca, and 0.8-1.6% P.

C. Diets for cats?

1) Can be fed a feline reproduction and growth diet throughout pregnancy but is needed especially during the last 3 wk of pregnancy and during lactation.
2) The diet on DM basis should be at least 80% digestible & contain at least 35% CP, 17% fat, 1,800 kcalME/lb, 1-1.8% Ca, and 0.8-1.6% P.

D. Some tips?

1) Should not be given any supplements (e.g., meat, milk, Ca, P, or vitamins) or fed anything other than a good quality diet meeting the specifications.
2) Ones with optimum body wt at breeding should be fed the same amount needed for maintenance during the first 5 to 6 wk of pregnancy.
3) After 5 to 6 wk, the amount fed should be gradually increased so that the dam is getting 15 to 25% more energy by parturition time. (Free-choice or twice a day?)
5) During the lactation phase:

a) Feed at least three times a day or free-choice to maintain optimum body wt.
b) Feed 1.5, 2, and 3 times the maintenance during the 1st, 2nd, and 3rd wk of lactation to weaning, respectively.
c) Encourage the young to begin eating solid food at 3 wk of age to assist the dam in maintaining her optimum body wt during peak lactation (3rd through 6th wk).

4. Feeding and Raising Young Dogs and Cats

A. Orphan puppies and kittens

1) Environment - Need a separate quarter for each young dog or cat, and the temperature for the 1st 7 days should be 85° to 90°F, 80°F for the next 2 to 3 wk, and 75°F by the 4th wk. Bedding should be cleaned daily to prevent skin rash.
2) Milk replacer - Need a diet formulated to satisfy the nutritional needs of the young, and various modifications of homemade & commercially prepared formulas simulating the dam's milk have been used with good success.
3) Methods of feeding?

a) General:

(1) Keep all equipment scrupulously clean.
(2) Do not prepare more than needed to feed for a 48-hour period, and divide the formula into portions & store in refrigerator.
(3) Warm the formula to about 100°F or near body temperature before feeding.

b) Nipple bottle feeding - Nipple bottles made especially for feeding orphan puppies or kittens are preferred.
c) Tube feeding - The easiest, cleanest, fastest, safest, and most preferred way to feed the orphan puppy or kitten.
d) Supplemental feeding:

(1) Try to encourage the young to eat some solid food.
(2) May want to mix water with the solid food to make a thick mushy gruel.
(3) Smear some of the gruel on the animal's lips.
(4) Once they are eating from a bowl, gradually decrease the amount of water mixed with the food until only the solid food is fed three times a day.

B. Weanling puppies and kittens

1) Feed the weanlings a diet 3 to 4 times daily.
2) Wean at 4 to 7 wk of age (5½ to 6 wk is the average) and allow 7-10 days for the weaning process.
3) Often, the dam will start to wean on her own due to the irritation caused by the presence of animals' teeth and toenails.
4) Take the dam from the young in the daytime for the first few days, putting her back with the young at night - Gradually take her away for longer periods so she will finally wean them permanently.

C. Older puppies and kittens

1) Feed three times & twice a day for the fist 3 mo & 6 mo, respectively.
2) Dogs and cats that are 8 mo to 1 year and older may be fed once daily - May feed them twice a day if they aren't fed too much at a time.

5. **Feeding and Caring for Aging Dogs and Cats**

A. Geriatric nutrition?

1) Difficulty in providing a geriatric diet? - Cannot use a general definition for the geriatric animal.
2) Little scientific info available on the nutrition of geriatric dogs and cats, but according to one report, geriatric dogs may be just as capable in digesting and metabolizing nutrients vs. young dogs.

3) Contrary to popular belief, older animals do not have different dietary needs vs. younger animals.

B. Reduce protein?

1) Some pet foods are formulated to contain less protein based on the idea that the dietary protein may contribute to the onset of or progression of kidney insufficiency.
2) Recent research show that increased dietary protein did not increase their risk for developing renal disease.
3) Older animals may even have a higher protein needs vs. young animals, and dietary protein should not be restricted below amounts provided for adult maintenance.

C. Some considerations?

1) Early detection of nutritional disturbances and proper nutritional management thereafter may slow or prevent the progression of organ failures and possibly slow the aging process.
2) Good oral hygiene is important in ensuring adequate food intake and utilization.
3) The amount fed should satisfy hunger but should not result in unnecessary abdominal distension and discomfort. Feed small meals at least twice a day (on a regular schedule) of a palatable & highly digestible diet.
4) A diet for a normal aged dog? On a DM basis, at least 80% digestible & contains at least 14 to 21% CP, 10% fat, 1,700 kcal ME/lb, less than 4% fiber, 0.5 to 0.8% Ca, 0.4 to 0.7% P, and 0.2 to 0.4% Na, and be of good quality.
5) A diet for a normal aged cat? On a DM basis, at least 80% digestible & contains at least 25 to 35% CP, 15% fat, 1,700 kcal ME/lb, less than 4% fiber, 0.5 to 0.8% Ca, 0.4 to 0.7% P, 0.2 to 0.4% sodium, less than 0.10% Mg, and be of good quality.
6) Older dogs/cats may have a reduced appetite & digestive/absorption ability. If so, should be fed palatable high-energy diets at frequent intervals.
7) Important for the aged dog or cat to have adequate physical activity to maintain muscle tone, enhance circulation, and improve waste elimination.

6. Nutritional Problems

A. Obesity

1) Obesity is currently the most common nutritional problem in digs/cats in the US.

a) Dogs and cats are considered obese when they are 10-15% above their optimum body weight.
b) More common in female than male dogs up to 12 yr of age and is about twice as high in neutered dogs of both sexes.
c) Beagles, cocker spaniels, collies, dachshunds, and Labradors have the highest incidence of obesity.

d) Obesity in cats is equally common in both sexes with higher incidence in older neutered cats.

2) Can result in chronic health problems & reduced longevity because of locomotion problems/bone & joint disease, diabetes mellitus, cardiovascular disease, hypertension, heat intolerance, altered resistance, and many others.
3) Causes? Factors such as endocrine imbalances and abnormal responsive taste that interfere with internal body signals are rare, thus perhaps, overfeeding for whatever the reason and insufficient exercise might be the primary causes!?
4) Method for weight reduction?

a) Should be considered for all dogs & cats that are more than 15% above their optimum weight to decrease health problems, reduce future health care costs, improve appearance, and increase the animal's enjoyment and length of life.
b) Goals - First reduce body fat stores and attain normal body weight & then maintain the weight for the remainder of the pet's life!
c) Exercise - Quite helpful, not only in increasing energy expenditures but also reduces appetite & food intake.
d) Methods for weight reduction program for the obese animal include:

(1) Decrease the regular commercial diet by 50% of that needed for the maintenance of the initial (obese) body weight.
(2) Feed the regular commercial diet at 60% for dogs and 66% for cats of that needed for the maintenance of optimum body weight
(3) Feed a nutritionally complete and balanced high-fiber, low-energy diet.
(4) Feed at least three times a day with the amount fed restricted to feeding times.
(5) Keep palatable water available at all times.
☛ Exclude all table scraps, snacks, sweets, etc., and also avoid total fasting or starvation for quick weight reduction.

B. Nutritional problems in the cat eating commercial dog foods

1) Develop malnutrition in the adult cat when all the basic nutritional needs are not being met, and a common cause may be a continuous ingestion of commercially prepared, cereal-based dog foods?
2) The cat's nutritional needs are quite different from those of the dog as mentioned before:

a) The cat has a much higher protein requirement than the dog.
b) Little dietary arginine is needed by the mature dog but the cat will die within hours after consuming an arginine-free diet.
c) Cats require taurine in the diet - Inadequate taurine results in central retinal degeneration and blindness.

d) Cats cannot convert linoleic acid to arachidonic acid, thus must consume preformed arachidonic acid. If not, develop a dry lusterless hair coat or, if severe deprivation is present, emaciation and spots of moist dermatitis develop.
e) Cats cannot convert beta carotene in plants to vitamin A, thus must consume preformed vitamin A.
f) Cats cannot convert the amino acid Trp to the B vitamin, niacin, and, therefore, require more niacin in the diet.

3) Primary treatment is to feed a nutritionally balanced commercially prepared or homemade diet formulated for cats.
4) Cats in general should not be fed any single food item or cat food consisting of a single food item, such as some of the gourmet cat foods, at more than 25% of the cat's total food intake.

PET FOOD LABELS

1. General

A. A pet food label contain a tremendous amount of useful information, and can be used to distinguish a quality product from inferior products if interpreted correctly.

B. The information required on the label is prepared and approved by the joint federal and state AAFCO, and requires:

1) The product name,
2) The net weight,
3) An ingredient list,
4) A guaranteed analysis,
5) The name and address of the manufacturer, packer, or distributor,
6) Designation of "Dog Food" or "Cat Food," and
7) A statement describing the purpose of the product and the method used to determine its adequacy.

2. Nutritional Statements

A. Provide ingredient lists & guaranteed analyses, but lack specific info on the content and availability of many nutrients.

   1) Possible to have "two labels" to have identical info, yet the nutritional value could be totally different!
   2) Differences in processing methods and selection of quality raw materials can have an impact on the quality, thus one product can be superior while another can be totally unsatisfactory.

B. Product literature as consumer education tool - Can be provided by some manufacturers but certainly not by all!
C. Perhaps, the reputation of the pet food manufacturer and information concerning animal nutrition testing of a product may assist in product selection.
D. The claim of nutritional adequacy:

   1) With the exception of teats & snacks, all pet foods that are interstate commerce must contain a statement & validation of nutritional adequacy.
   2) With the "complete and balanced nutrition" claim, manufacturers must indicate the method used to substantiate the claim.

3. **Nutritional Adequacy**

A. According to AAFCO regulations, manufacturers can validate the nutritional adequacy in one of the two ways.
B. First one is to perform "AAFCO sanctioned feeding trials" on food:

   1) Most thorough & reliable method.
   2) Terms included such as "feeding tests," "AAFCO feeding test protocols," or "AAFCO feeding studies" in a label claim indicate that the product has been tested.

C. Second one is to "formulate the diet to meet the AAFCO Nutrient Profiles for Dog and Cat Foods:"

   1) Allows the manufacturers to substantiate the claim by merely calculating the nutrient content of the formulation using standard tables of ingredients without laboratory analyses or feeding trial.
   2) Although some manufacturers using this method may still conduct some own feeding trial, but consumers wouldn't know that from the label.

3. **Physical Evaluation of Pet Food**

A. Evaluation of the package or container:

   1) Dry & semimoist foods - Should be provided in tightly sealed multilayer packages.

2) An inner liner aids in prevention of moisture migration, fat wicking, and infestation, and also keeping product aroma in to maintain palatability.
3) Canned foods with dented or swollen - May indicate bacteria fermentation, thus should not be fed?

B. Product appearance should meet the standard:

1) Consider consistency of product color, size & shape, as well as pleasant aroma.
2) Presence of foreign materials (including ingredient-related such as hair, feathers, etc.) - Indication of inadequate quality assurance program?

4. Palatability Evaluation

A. Simply because, if not consumed, even the most nutritious food is of no benefit, pet foods are routinely tested for acceptability - Usually by offering an animal two products, one of which is a control of known acceptability.
B. Product odor, taste, texture, shape, and moisture content affect the palatability.
C. Highly palatable foods may not be always the most nutritious though!

1) For instance, palatability for cat foods can be enhanced by adding palatable ingredients such as garlic & cheese powder or phosphoric acid, but they may not have any nutritional value.
2) In fact, a highly palatable food may lead to eating more than its energy needs, thus resulting in obesity!

NUTRIENT REQUIREMENT TABLE FOR FISH, AND DOG & CAT FOOD PROFILE TABLES

[Based on NRC (1993) & AAFCO (1994/2001, Cited by Hirakawa (1998), Corbin (2001), and Jurgens (2002)]

1. Table 1. Nutrient Requirements for Channel Catfish, Rainbow Trout, Pacific Salmon, Common Carp, and Tilapia (As-Fed Basis)[a] (NRC, 1993)

Species:	Channel Catfish	Rainbow Trout	Pacific Salmon	Common Carp	Tilapia
Energy[b] (kcal DE/kg diet)	3,000	3,600	3,600	3,200	3,000
Crude Protein (digestible), %	32 (28)	38 (34)	38 (34)	35 (30.5)	32 (28)
Amino acid, %					
Arginine	1.20	1.50	2.04	1.31	1.18
Histidine	0.42	0.70	0.61	0.64	0.48
Isoleucine	0.73	0.90	0.75	0.76	0.87
Leucine	0.98	1.40	1.33	1.00	0.95
Lysine	1.43	1.80	1.70	1.74	1.43
Methionine + cystine	0.64	1.00	1.36	0.94	0.90
Phenylalanine + tyrosine	1.40	1.80	1.73	1.98	1.55
Threonine	0.56	0.80	0.75	1.19	1.05
Tryptophane	0.14	0.20	0.17	0.24	0.28
Valine	0.84	1.20	1.09	1.10	0.78
n-3 fatty acids, %	0.5-1.0	1.0	1.0-2.0	1.0	-
n-6 fatty acids, %	-	1.0	-	1.0	0.5-1.0
Macrominerals, %					
Calcium	R	1.0E	NT	NT	R
Chlorine	R	0.9E	NT	NT	NT
Magnesium	0.04	0.05	NT	0.05	0.06
Phosphorus	0.45	0.60	0.60	0.60	0.50
Potassium	R	0.7	0.8	NT	NT
Sodium	R	0.6E	NT	NT	NT
Microminerals, mg.kg					
Copper	5	3	NT	3	R
Iodine	1.1E	1.1	0.6-1.1	NT	NT
Iron	39	60	NT	150	NT
Manganese	2.4	13.0	R	13.0	R
Zinc	20	30	R	30	20
Selenium	0.25	0.30	R	NT	NT
Fat-soluble vitamins					
Vitamin A, IU/kg	1,000-2,000	2,500	2,500	4,000	NT
Vitamin D, IU/kg	500	2,400	NT	NT	NT
Vitamin E, IU/kg	50	50	50	100	50
Vitamin K, mg/kg	R	R	R	NT	NT
Water-soluble vitamins, mg/kg					
Riboflavin	9	4	7	7	6
Pantothenic acid	15	20	20	30	10
Niacin	14	10	R	28	NT
Vitamin B_{12}	R	0.01E	R	NR	NR
Choline	400	1,000	800	500	NT
Biotin	R	0.15	R	1	NT
Folate	1.5	1.0	2.0	NR	NT
Thiamin	1	1	R	0.5	NT
Vitamin B_6	3	3	6	6	NT
Myoinositol	NR	300	300	440	NT
Vitamin C	20-50	50	50	R	50

☞ NOTE: These requirements have been determined with highly purified ingredients in which the nutrients are highly digestible, therefore the values presented represent near 100 percent bioavailability. [a]R, required in diet but quantity not determined; NR, no dietary requirement demonstrated under expertmental conditions; NT, not tested; and E, estimated. [b]Typical energy concentrations in commercial diets.

2. Table 2. Association of American Feed Control Officials (AAFCO) Dog Food Nutrient Profiles (Dry Matter Basis)[a] [Hirakawa (1998), Corbin (2001), and Jurgens (2002)]

Nutrient	Unit	Growth & Reproduction Minimum	Adult Maintenance Minimum	Maximum
Crude Protein	%	22.0	18.0	
Arginine	%	0.62	0.51	
Histidine	%	0.22	0.18	
Isoleucine	%	0.45	0.37	
Leucine	%	0.72	0.59	
Lysine	%	0.77	0.63	
Methionine-cystine	%	0.53	0.43	
Phenylalanine-tyrosine	%	0.89	0.73	
Threonine	%	0.58	0.48	
Tryptophan	%	0.20	0.16	
Valine	%	0.48	0.39	
Crude Fat[b]	%	8.0	5.0	
Linoleic acid	%	1.0	1.0	
Minerals				
Calcium	%	1.0	0.6	2.5
Phosphorus	%	0.8	0.5	1.6
Ca:P ratio		1.1	1:1	2:1
Potassium	%	0.6	0.6	
Sodium	%	0.3	0.06	
Chloride	%	0.45	0.09	
Magnesium	%	0.04	0.04	0.3
Iron[c]	mg/kg	80	80	3,000
Copper[d]	mg/kg	7.3	7.3	250
Manganese	mg/kg	5.0	5.0	
Zinc	mg/kg	120	120	1,000
Iodine	mg/kg	1.5	1.5	50
Selenium	mg/kg	0.11	0.11	2
Vitamins & Other				
Vitamin A	IU/kg	5,000	5,000	250,000
Vitamin D	IU/kg	500	500	5000
Vitamin E	IU/kg	50	50	1000
Thiamine[e]	mg/kg	1.0	1.0	
Riboflavin	mg/kg	2.2	2.2	
Pantothenic acid	mg/kg	10	10	
Niacin	mg/kg	11.4	11.4	
Pyridoxine	mg/kg	1.0	1.0	
Folic acid	mg/kg	0.18	0.18	
Vitamin B_{12}	mg/kg	0.022	0.022	
Choline	mg/kg	1200	1200	

[a]Presumes an energy density of 3,500 kcal ME/kg, as determined in accordance with Regulation PF9. Rations greater than 4,000 kcal ME/kg should be corrected for energy density. Diets less than 3,500 kcal ME/kg should not be corrected for energy. Diets of low-energy density should not be considered adequate for growth or reproductive needs based on comparison to the Profiles alone. [b]Although a true requirement for crude fat per se has not been established, the minimum level was based on recognition of crude fat as a source of essential fatty acids, as a carrier of fat-soluble vitamins, to enhance palatability, and to supply an adequate caloric density. [c]Because of very poor bioavailability, iron from carbonate or oxide sources that are added to the diet should not be considered in determining the minimum nutrient level. [d]Because of very poor bioavailability, copper from oxide sources that are added to the diet should not be considered in determining the minimum nutrient level. [e]Because processing may destroy up to 90% of the thiamine in the diet, allowances in formulation should be made to ensure the minimum nutrient level is met after processing.

3. Table 3. AAFCO Cat Food Nutrient Profiles (Dry Matter Basis)[a] [Hirakawa (1998), Corbin (2001), and Jurgens (2002)]

Nutrient	Unit	Growth & Reproduction, Minimum	Adult Maintenance, Minimum	Maximum
Crude Protein	%	30.0	26.0	
Arginine	%	1.25	1.04	
Histidine	%	0.31	0.31	
Isoleucine	%	0.52	0.52	
Leucine	%	1.25	1.25	
Lysine	%	1.20	0.83	
Methionine-cystine	%	1.10	1.10	
Methionine	%	0.62	0.62	1.5
Phenylalanine-tyrosine	%	0.88	0.88	
Phenylalanine	%	0.42	0.42	
Threonine	%	0.73	0.73	
Trytophan	%	0.25	0.16	
Valine	%	0.62	0.62	
Crude Fat[b]	%	9.0	9.0	
Linoleic acid	%	0.5	0.5	
Arachidonic acid	%	0.02	0.02	
Minerals				
Calcium	%	1.0	0.6	
Phosphorus	%	0.8	0.5	
Potassium	%	0.6	0.6	
Sodium	%	0.2	0.2	
Chloride	%	0.3	0.3	
Magnesium[c]	%	0.08	0.04	
Iron[d]	mg/kg	80	80	
Copper (extruded)	mg/kg	15	5	
Copper (canned)	mg/kg	5	5	
Manganese	mg/kg	7.5	7.5	
Zinc	mg/kg	75	75	2000
Iodine	mg/kg	0.35	0.35	
Selenium	mg/kg	0.1	0.1	
Vitamins & Others				
Vitamin A	IU/kg	9,000	5,000	750,000
Vitamin D	IU/kg	750	500	10,000
Vitamin E	IU/kg	30	30	
Vitamin K	mg/kg	0.1	0.1	
Thiamine	mg/kg	5.0	5.0	
Riboflavin	mg/kg	4.0	4.0	
Pantothenic acid	mg/kg	5.0	5.0	
Niacin	mg/kg	60	60	
Pyridoxine	mg/kg	4.0	4.0	
Folic acid	mg/kg	0.8	0.8	
Biotin	mg/kg	0.07	0.07	
Vitamin B_{12}	mg/kg	0.02	0.02	
Choline	mg/kg	2,400	2,400	
Taurine (extruded)	%	0.10	0.10	
Taurine (canned)	%	0.20	0.20	

[a]Presumes an energy density of 4,000 kcal ME/kg as determined in accordance with Regulation PF9. Rations greater than 4,500 kcal ME/kg should be corrected for energy density; diets ess than 4500 kcal ME/kg should not be corrected for energy. Diets of low-energy density should not be considered adequate for growth or reproductive needs based on comparison to the Profiles alone. [b]Although a true requirement for crude fat per se has not been established, the minimum level was based on recognition of crude fat as a source of essential fatty acids, as a carrier of fat-soluble vitamins, to enhance palatability, and to supply an adequate caloric density. [c]If the mean urine pH of cats fed ad libitum is not below 6.4, the risk of struvite urolithiasis increases as the magnesium content of the diet increases. [d]Because of very poor bioavailability, iron from carbonate or oxide sources are added to the diet should not be considered in determining the minimum nutrient level.